# Evaluating New Technology

## A Risk Assessment Problem

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# Production Cost Hierarchy

**TODAY**

- Materials
- Overhead
- Direct Labor
- Transportation
- Energy

**FUTURE**

- Materials
- Energy
- Direct Labor
- Overhead
- Transportation

# The Risk Assessment Model

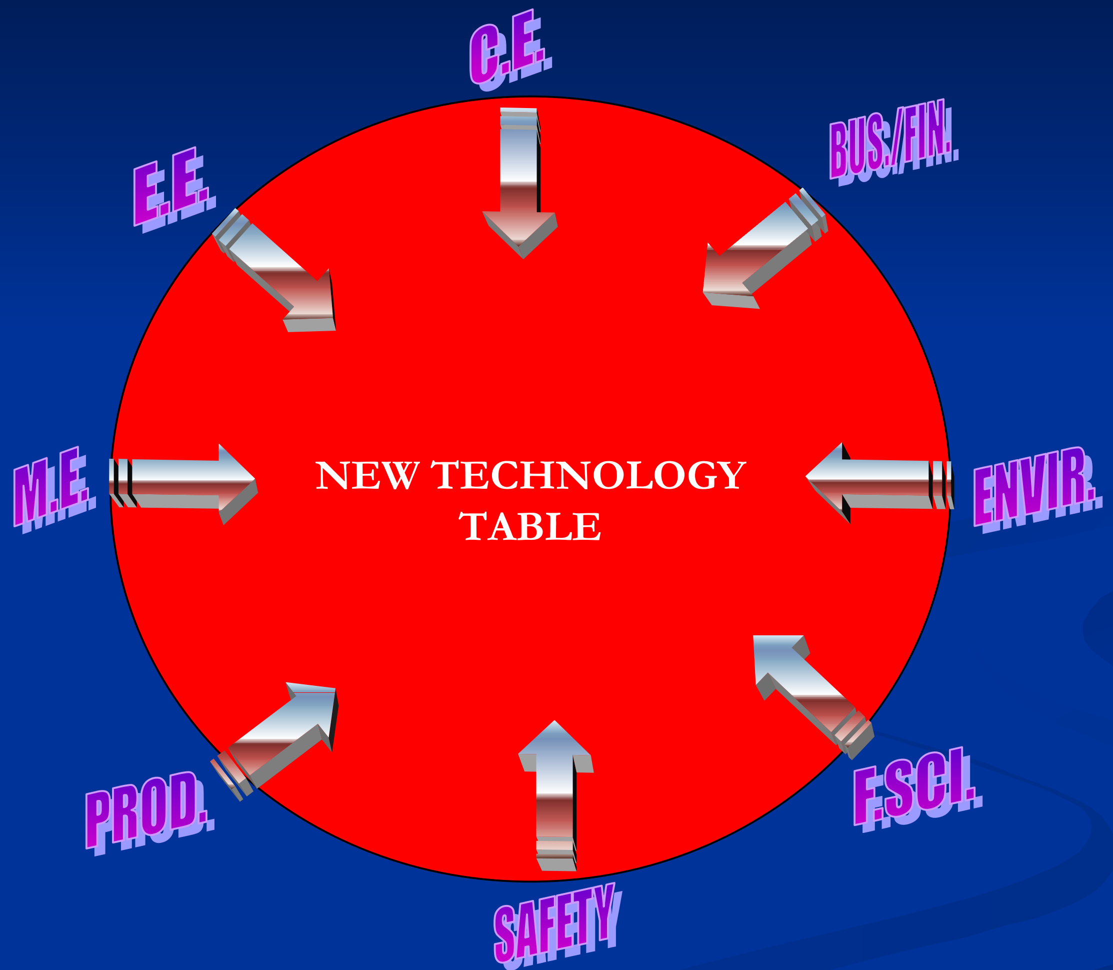
**SAFETY**

- Target – parameter to be protected
- Tolerance – acceptable risk limit
- Foreseeable Hazards
- Assess Risk – probablility x severity
- Resolution

**TECHNOLOGY**

- Required Function
- Variance in Functional requirements
- FMEA/FTA
- Evaluate via Decision Matrix
- Resolution

# PERSPECTIVE TABLE



# CROSS FUNCTIONAL TEAM

Must have a team to remove skewed perspectives:

- DEVELOP DECISION MATRIX – Why?
  - filter out personal predjudices.
  - Can't rely solely on "intuition" of engineers.
  - Develop function variants and respective weighting factors to be agreed upon by the team.
  - Each team member has equal say
- LEADERSHIP – Facilitator, not "My ideas are best"

# TEAM - PARTNERSHIPS

- Minimize risk by developing partnerships or alliances
- Could be technology specific
- Expertise could come from other industry
- Pilot Plants – help absorb cost & gather process & operations data
- Universities/Technical Institutions – UC Davis, USU

HOWEVER – “YOU MUST DRIVE THE DEVELOPMENT PROCESS”

e.g. DFA/Stork Food & Dairy Systems;
Hormel/Asep-Tech USA

# Developing "THE TARGET"

- Requirements List:
  - Concept – demands (must, shall) and wishes (should, may)
  - Embodiment – concrete, quantitative
- Explicitly Define Expected Benefits - must have an in-depth understanding of existing technology as a baseline metric.
- Recognize Lifecycle Cost vs Development Cycle
- ROI/Operating Cost should be considered as a functional requirement.

# Objective Tree



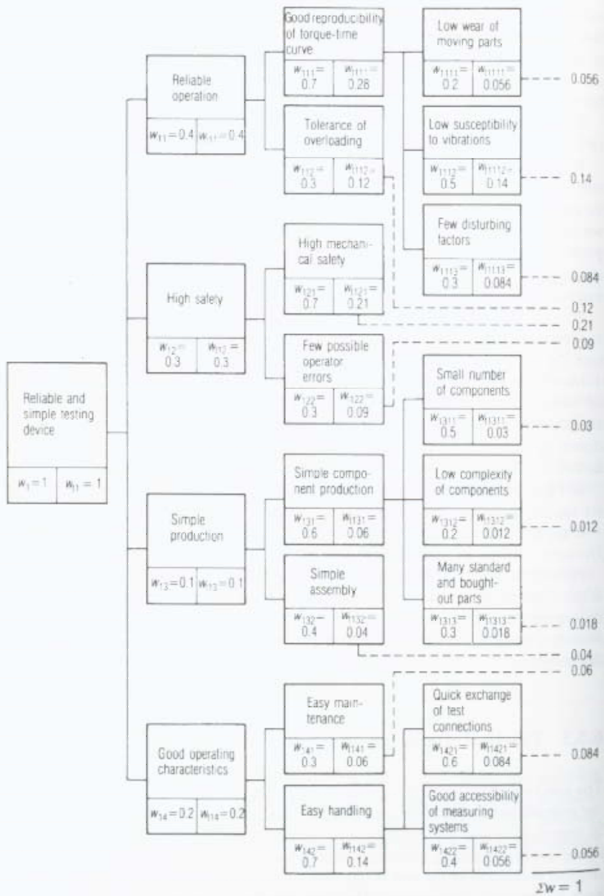



**Figure 6.33.** Objectives tree for impulse-loading test rig.

# Evaluation Methods

- Delphi Method:
  - Industry experts are engaged to provide written opinions. (Partnerships)
- Selection/Rating Methods
  - Economic Criteria
  - Technical Criteria
  - Weighting the Evaluation Criteria - IMPORTANT
- "Search for Weak Spots" – indicated by an unbalanced value profile.

# Variant Analysis-The Decision Matrix

| No. | Evaluation criteria | Wt. | Parameters | Unit | Variant $V_1$ Magn. $m_{i1}$ | Variant $V_1$ Value $v_{i1}$ | Weighted value $wv_{i1}$ | Variant $V_2$ Magn. $m_{i2}$ | Variant $V_2$ Value $v_{i2}$ | Weighted value $wv_{i2}$ | Variant $V_3$ Magn. $m_{i3}$ | Variant $V_3$ Value $v_{i3}$ | Weighted value $wv_{i3}$ | Variant $V_4$ Magn. $m_{i4}$ | Variant $V_4$ Value $v_{i4}$ | Weighted value $wv_{i4}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Low wear of moving parts | 0.056 | Amount of wear | - | high | 3 | 0.168 | low | 6 | 0.336 | average | 4 | 0.224 | low | 6 | 0.336 |
| 2 | Low susceptibility to vibrations | 0.14 | Natural frequency | $s^{-1}$ | 410 | 3 | 0.420 | 2370 | 7 | 0.980 | 2370 | 7 | 0.980 | < 410 | 2 | 0.280 |
| 3 | Few disturbing factors | 0.084 | Disturbing factors | - | high | 2 | 0.168 | low | 7 | 0.588 | low | 6 | 0.504 | (average) | 4 | 0.336 |
| 4 | Tolerance of overloading | 0.12 | Overload reserve | % | 5 | 5 | 0.600 | 10 | 7 | 0.840 | 10 | 7 | 0.840 | 20 | 8 | 0.960 |
| 5 | High mechanical safety | 0.21 | Expected mechan. safety | - | average | 4 | 0.840 | high | 7 | 1.470 | high | 7 | 1.470 | very high | 8 | 1.680 |
| 6 | Few possible operator errors | 0.09 | Possibilities of operator errors | - | high | 3 | 0.270 | low | 7 | 0.630 | low | 6 | 0.540 | average | 4 | 0.360 |
| 7 | Small number of components | 0.03 | No. of components | - | average | 5 | 0.150 | average | 4 | 0.120 | average | 4 | 0.120 | low | 6 | 0.180 |
| 8 | Low complexity of components | 0.012 | Complexity of components | - | low | 6 | 0.072 | low | 7 | 0.084 | average | 5 | 0.060 | high | 3 | 0.036 |
| 9 | Many standard and bought-out parts | 0.018 | Proportion of standard and bought-out components | - | low | 2 | 0.036 | average | 6 | 0.108 | average | 6 | 0.108 | high | 8 | 0.144 |
| 10 | Simple assembly | 0.04 | Simplicity of assembly | - | low | 3 | 0.120 | average | 5 | 0.200 | average | 5 | 0.200 | high | 7 | 0.280 |
| 11 | Easy maintenance | 0.06 | Time and cost or maintenance | - | average | 4 | 0.240 | low | 8 | 0.480 | low | 7 | 0.420 | high | 3 | 0.180 |
| 12 | Quick exchange of test connections | 0.084 | Estimated time needed to exchange test connections | min | 180 | 4 | 0.336 | 120 | 7 | 0.588 | 120 | 7 | 0.588 | 180 | 4 | 0.336 |
| 13 | Good accessibility of measuring systems | 0.056 | Accessibility of measuring systems | - | good | 7 | 0.392 | good | 7 | 0.392 | good | 7 | 0.392 | average | 5 | 0.280 |
| | | $\Sigma w_i = 1.0$ | | | | $OV_1 = 51$ $R_1 = 0.39$ | $OWV_1 = 3.812$ $WR_1 = 0.38$ | | $OV_2 = 85$ $R_2 = 0.65$ | $OWV_2 = 6.816$ $WR_2 = 0.68$ | | $OV_3 = 78$ $R_3 = 0.60$ | $OWV_3 = 6.446$ $WR_3 = 0.64$ | | $OV_4 = 68$ $R_4 = 0.52$ | $OWV_4 = 5.388$ $WR_4 = 0.54$ |

# Evaluation Rating

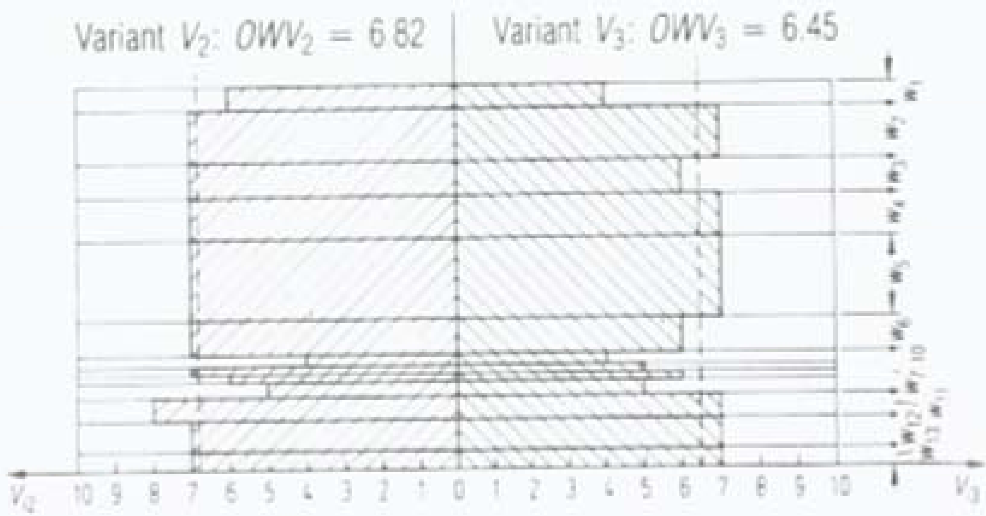



Figure 6.35. Value profile for detection of weak spots.

# FMEA/FTA

- FMEA:
  - What are the effects of failure?
  - How can we quantify the effects?  ($, downtime, waste, lost efficiency, etc.)
- FTA:
  - Assume faults and identify conditions that would cause that event.
  - Revise requirements list to remove flaws.
- Engineering Models
- Testing/Pilot Facilities – obtain real, scalable data for:
    - Development of failure probabilities.
    - Develop basis for production rates.
    - Develop energy models; efficiency, consumption, waste, for full scale system

# FMEA CHART

TU-Berlin

Failure Mode and Effect Analysis
Design (product)–FMEA ☒ Process-FMEA ☐

Name/ Department/ Supplier/ Telephone
Institute for Machine Design-Engineering Design

Component name
Cylindrical cam

By (Name/ Department/ Telephone)
Mr Wende

| Failure location/characteristic | Failure type | Failure consequence | Failure cause | Current situation: Proposed test steps | O | S | D | RN | Suggested remedial measures | Improved situation: Applied steps | O | S | D | RN |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Shaft | Shaft fracture | Complete breakdown | Type of loading not identified correctly | | 3 | 10 | 10 | 300 | Determine loading using suitable calculations | Proof of strength of the shaft | 1 | 10 | 10 | 100 |
| Bearing | Play in bearing assembly | Imprecise function fulfilment | Slacking of shaft nut during operation (impulse loading) | | 3 | 8 | 10 | 240 | Additional locking of the shaft nut | | 1 | 8 | 10 | 80 |
| | Sealing leakage | Early wear of bearings | Sealing not as required | | 2 | 5 | 10 | 100 | Use of radial shaft seals recommended by DIN | | 1 | 5 | 10 | 50 |
| Shaft-hub-connection (flange-bolt connection) | Insufficient frictional fit | Shear stress in bolts | Layout error (friction values neglected) | | 2 | 6 | 10 | 120 | Application of a sufficiently high safety factor | | 1 | 6 | 10 | 60 |
| | Precision of fittings | Joining not possible or centring insufficient | Design fault | | 2 | 5 | 1 | 10 | Check tolerance calculation | | 1 | 5 | 1 | 5 |
| | Failure of bolts | Complete breakdown | Type of loading not identified correctly | | 3 | 10 | 10 | 300 | Suitable calculation for loading situation | Appropriate bolt dimensions | 1 | 10 | 10 | 100 |
| Cylindrical cam | Surface pressure too high | Pitting in the running surface | Lever pressure on surface too high | | 7 | 8 | 10 | 560 | Suitable combination of materials and adapted geometry | | 2 | 8 | 10 | 160 |

**O:** Occurrence

**Probability of occurrence** (failure can exist)

- very low = 1
- medium low = 2–3
- medium = 4–6
- medium high = 7–8
- high = 9–10

**S:** Significance

**Effect on customers**

- effects hardly noticeable = 1
- failures not important (little trouble to the customer) = 2–3
- reasonably serious failure = 4–6
- serious failure (annoying for the customer) = 7–8
- failure with large negative effects = 9–10

**D:** Detection

**Probability of detection** (before delivery to customers)

- high = 1
- medium high = 2–5
- medium = 6–8
- medium low = 9
- low = 10

**RN:** Risk number

- *high = 1000*
- *medium = 125*
- *no risk = 1*

# Technology Readiness

- Can the Technology be implemented w/ existing support processes?
- Are critical parameters that control the process be identified? (functional dependence/independence)
- Are the safe operating latitude and sensitivity of the parameters known?
- Have the failure modes been identified?
- Does hardware exist that demonstrates positive answers to the above four questions? (lab models, similar designs, pilot plants, etc.)
- Is the technology controllable throughout the lifecycle? (by-products, waste management, process degradation, etc.)

# Rules of Thumb

- Simplicity – The most simple device/system embodiment that fulfills the functional requirements will always be the most efficient and reliable. (the "KISS" principle)
- Design to Standards (FDA, USDA, AIB, etc.) as a MINIMUM
- In order to effectively evaluate design variants using these techniques, each must be at an equal level of design detail.
- Entropy (Disorganization) Should Always be Minimized – This is an organizational "attitude".
  - Thermal systems "second law efficiency" is maximized.
  - Other systems: minimize #of movements – pertains to workflow and organization.

# SUMMARY

- Minimize risk of loss (production, efficiency, etc.) by use of a systematic approach to the evaluation process.
- Risk is minimized by carefully weighting the functional requirements – Using real data to develop weighting factors.
- The Process is iterative based on knowledge and level of detail.
- Develop failure probablities by modeling (FMEA) and Testing (Pilot/Lab)
- Decisions are based on a systematic, logical and well documented method.